



¿How to learn Thematic Cartography in the context of Geosciences and Engineering? Towards a new pedagogical proposal

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Abstract: This paper aims to expose the development of a educational proposal supported in the use of ICT, adopting for this purpose the methodology of instructional design ADDIE, widely used in the design and development of e-learning courses, which offer the possibility of analyzing the results obtained from an individual assessment of each one of these phases and make the feedback respective to the whole process, therefore it allowing assess the effectiveness of the training in terms of its quality and relevance in the academic and professional work of learners, with the goal of helping the process of teaching-learning of Thematic Cartography applied to the study of Geosciences through the design and implementation of a free course in a virtual environment. In this sense the course allows to highlight the scope of the thematic map as a support tool for smart land management in Colombia. The final result is a theoretical and practical virtual course proposed to be developed over a period of five weeks with a total of fifty hours of academic work by the learner, oriented to facilitate the appropriation of concepts, criteria and techniques for reading and apply graphical representation of geospatial information, used and produced in the theme of Geosciences and the use of web tools for geo-visualization and publication. Likewise, this paper offers a short discussion of the opportunities and challenges that involve the course construction, to join efforts that motivate innovation and continuous improvement in transfer quality knowledge in this discipline.

Keywords: pedagogical proposal, e-learning, thematic cartography, geosciences, ICT, virtual course.

1. Introduction

1.1 Why a course of thematic cartography applied to Geoscience, supported by the ICT?

The necessity of presenting, publishing and share useful information for the spatial comprehension in the different areas of knowledge that use of geographic information and considering that the objective of Geosciences decrease on the physical study, in a space-time frame, of the Earth system and its relationship with the anthropic activity, therefore the Earth sciences are one of the main disciplines where producers and consumers of the spatial information need to know how to visualize and represent data by thematic cartography. On the other hand in Colombia is evident the deficient academic offer on a virtual environment as a complementary formation, focused on students and professionals interested in study these disciplines regarding to appropriation of concepts, methodologies and the use of innovative technological tools for the cartographic design, representation and publishing of thematic information in an effective way.

One key aspect that deserves to be attended, responds to the frequent errors of thematic representation in cartographic documents published by official and non-official of national and regional Organizations in Colombia. This

errors are related to especially two elements: the way in which the visual variables are introduced in the characterization of thematic units and how the information to be presented (level of synthesis considering the map's purpose) (Bertin 1987), therefore in thematic cartography one of the biggest mistakes and that conduces to imprecise readings of the phenomenon to study consist of representing it with redundancy of variables and this situation perhaps suggests that the lack of awareness of the perceptive properties of the variables have a considerable influence on the thematic illegible maps production. "This situation could be explained by the lack of lectures in the universities and lack of texts, especially in Spanish, about thematic cartography". (Flórez and Thomas 1992)

On the other hand, some educational programs include on their study plan at least one space on basic Cartography, which is structured and given face-to-face model using the normal lecture and exposition of contents. This model implies that teaching Cartography and specifically thematic Cartography is conditioned to the availability of capacity on an academic space, installed capacity, physical structure (computers' lounge) and skilled human resource that time to time affects the performance and monitoring of the course. In effect, the control of learning in the traditional formation, typical of these academic spaces, the control is centered in the teacher and not of the student, where the last one plays the role of passive receptor of contents, depending to the style of teaching of the educator, situation that can be solved by incorporating Information and communication Technology (ICT) on learning of this discipline.

The principal argument about the expected impact in relationship to including ICT on education, as proposed by Coll (2008), is related to the role of these, in the called Society of Information, mentioning that in the new social, economic, cultural and political stage, facilitated by the ICT, the knowledge has transformed in the most precious merchandise of the all, and education in the way to obtain it. Its potential is unquestionable, because it has allowed that information in the new century, more portable, immediate and global, conditions that are necessary for education to evolve.

The Internet has changed on a radical form the way in which people learn. In one way, the availability of the information sources, on the other hand, the way in which they exchange all type data. The amazing technological advance are forming learning and interaction ways that had transformed into outdated pedagogic systems on schools and universities continue to promote analogical ways of educating: lineal, authoritarian, of knowledge validated by the academic authority, presences. (Ordúz et al. 2012)

One of the principal challenges of this century education, reside in comprehend the contemporary students, characterized by their creativity, dynamism, technological knowledge, and collaborative. In this sense, using ICT on the education field motivates important changes on the teacher practice, as it demands planning and restructuration of the activities made on the classroom for a better use of the new didactic environment (Valle López and López 2005; Ibáñez 2004); reason why, it is necessary to establish the emphasis on learning, more than teaching itself, and for that, the key is in stimulate the self and collaborative learning by the use of ICT (Ordúz et al. 2012).

These arguments shown the necessity of designing and implement a course on a free virtual environment with easy access, focused at the autonomy of the participant for the construction of their own learning, structured about a democratic philosophy of knowledge, to develop competences on the design and assertive cartographic representation and encourage the technical tools on the web platforms that provide the presentation and publishing of geospatial information underlying of Geosciences' study.

2. Methodology

The design and development of virtual courses implies to apply more exhaustive methodologies than in traditional courses, since it uses technology as a form to facilitate the teaching-learning process of the students. For this reason, the instructional design requires, as Belloch (2012) proposes, a systematic planning that involves the necessities, the development, the evaluation, the implementation and the materials maintenance and didactic strategies.

Thus, identified that the model of instructional design, matches the purpose of this project, corresponds to the ADDIE methodology (composed of five phases: analysis, design, development, implementation and evaluation) (Kruse 2002), to give the possibility to study the results obtained from an individual assessment of each of its phases and perform the respective feedback throughout the process (Ghirardini 2014; Belloch 2012), such, that allows evaluating the effectiveness of the instruction in terms of its quality and relevance in the academic and professional work of them participants.

2.1 Phases

The first two phases allow the study of the theoretical aspects that define the relevance of the statement, that is, the identification of current training needs and the formulation of the pedagogical strategy that solves them. Once meeting these considerations, and having characterized the styles of learning of the students starting from the testing of Kolb (1981) and Felder and Silverman (1988), we proceed to design the virtual learning objects, select the management system of learning that will host the pedagogical strategy and design the virtual environment in which learners and tutor will interact.

The following phases: development and implementation embrace, in first instance, the creation of objects of learning, based on the educational standard SCORM (Cortés 2009), model of reference for content of objects exchangeable, which defines its production, interoperability, reusability and adaptability (Parra 2005). Likewise, it covered all those tasks that allowed the implementation and maintenance of the didactic prototype on a learning management system, configuring all administrative functions necessary to offer pedagogical resources and learning activities; And the implementation of the prototype (understood as the effective delivery of instruction through the virtual environment) to what underlies the management and monitoring of academic performance of all students.

The final phase of the project is referred to the evaluation of the course. The objective of this consists in determining the quality of the offered learning objects, as well as relevance, structure and operation of them. In the same way, shows the study and analysis of the progress of participants based on the results of learning and skills acquired throughout the instruction (assessment supported by the Taxonomy of Bloom) (Krathwohl and Bloom 1964), and also shows the interpretation of the results of the opinion survey, which exposes the level of satisfaction and provides the observations and recommendations of the participants at the course.

3. Results

As a result of the design of the didactic strategy, this involved the analysis of necessity of training in thematic cartography, obtained from the approach of the research problem, the review of literature regarding the programmatic contents defined by important educational Institutions in Latin America that the subject is teaching face-to-face, available in the web, and a diagnostic test applied to a sample of 1100 people with different levels of knowledge, in which the participants must give solution to a problem situations associated to common mistakes of cartographic representation. In this way, essentially four requirements were identified as is shown in Table 1.

Table 1. Description of needs of training

Needs of training	Considerations
Geo-visualization trends applicable to the primary information from the study of Geosciences are not showing.	The introduction of internet and the continuous technology advances, the cartography nowadays offering modern tools for the representation and display of spatial data, and give the possibility of update and share them in collaborative environments almost in real time.

Disarticulation of the techniques of spatial statistics in the cartographic representation of the information coming from geosciences.	Current technics offer tools for the estimation, analysis and modeling of such phenomena through the geo-statistical study of the variables and how these variables are related in the space.
Incorrect handling of the mapping language.	Mistakes in the application of visual variables in the representation of thematic units on the maps published by official and non-official Organizations in Colombia.
Methodologies for mapping of geo-spatial phenomena, which contributes to its creator to choose the suitable means of graphic expression, are not presented.	Select the better resources for graphic expression, depending on the purpose of the map, which requires the development of legends that can be interpreted by individuals without skills in the mapping discipline.

According to which, this virtual course is designed to provide all participants criteria to develop skills associated with visual expression that allow to build graphic representations of spatial information through the correct use of cartographic language, contextualize in current trends, perspectives and standards for the production of thematic maps from a synthetic perception of their applicability in Geosciences and foment the reflection and discussion to improve the current procedures in the mapping of variables of different types.

Regarding to planning, this practical and theory virtual course was proposed to be developed over a period of five weeks with a total of fifty hours of academic work by the participants. The course was structured in four thematic modules to be attended with a dedication of ten hours per week, of which six hours concerning self-study and four to the collaborative work. The thematic module is composed by a set of didactic units for which has associated a group of activities for learning. The student is not able to access a new module, until he finishes the previous one.

Another result of the project is the design of the curriculum for the thematic cartographic virtual course as is shown in Table 2, a product of combining "task analysis" (used to improve performance or specific skills) and "topic analysis" (to identify and organize the course syllabus).

Table 2. Curriculum design

Thematic module	Didactic Units
Introduction to thematic cartography	The mapping communication; Concepts of thematic cartography; An overview of Cartographic design; The base map and the web cartography.
Graphic semiology	The graphics system; Visual variables and properties; The level of organization.
Methods and techniques of thematic representation	Statistical area and class intervals in mapping of quantitative data; classification methods for quantitative cartography; criteria for mapping of quantitative and qualitative data; techniques of representation mapping.
Production of thematic cartography applied to Geosciences	Chloropleth Maps; Isopleth Maps; Cartograms; Production and visualization of surfaces (3D maps).

In accordance with the pedagogical model, the types of learning to stimulate into this initiative, in response to the definition of the pedagogical model are: meaningful learning, self-directed learning and collaborative learning supported on a constructivist philosophy (Ilabaca 2004), where the educational process can be highly participatory by the learner, in such a way that, he builds knowledge from his autonomy and then attributes significance in his professional work. Furthermore, this course combined a pedagogical strategy of cognitive type framed in the training by competencies (Marin 2015), which incorporated the base problem learning strategy as the core of the process

(Bas Peña 2011). According to these considerations, the objectives were defined as a result of learning and the skills of training, such as:

- **Learning objectives:** 1. provide concepts and necessary considerations for the design of thematic maps, using correctly the graphic language; 2. present the theoretical foundations of graphic semiology and highlight its importance in the production of cartographic maps; 3. familiarize the student with the criteria and most common thematic representation techniques for mapping of Geosciences data; 4. to promote the use of web mapping tools that allow the student to optimize the workflow in the production of thematic cartography.
- **Learning outcomes:** 1. identify the nature of the information to be mapped and select the best strategy for its representation, based on the purpose of the map; 2. Produce quality and esthetic maps; 3. acquire skills in the management of technological tools in web environments for the development and publication of cartographic products; 4. use properly the elements of the graphics system in the characterization of thematic units of geospatial phenomena; 5. know and apply the criteria and techniques for the spatialization and graphic representation of the multiplicity phenomena associated to the study of Geosciences.
- **Generic skills of training:** 1. capacity of learning autonomously those elements conceptual and methodological defined in the course; 2. capacity of appropriate, share, compare and give feedback knowledge through discussion in spaces designed for socializing and discussion; 3. capacity of management and use of the ICT in its process of formation; 4. capacity of organization and planning for the development of the proposed learning activities, that will ensure the learning of the topics addressed in the course; 5. capacity of analysis, inventive and taking of decisions by stimulating the learning based in problems; 6. ability to adopt and apply the knowledge in their academic and professional work.
- **Specific training skills:** 1. capability of reading, interpretation and analysis of spatial information for the study of the geosciences through the use of graphic referenced documents; 2. improvement of spatial cognition and critical reasoning with cartographic basis; 3. ability to communicate assertively geospatial phenomena efficiently using the graphic language; 4. capacity of use those criteria and actions in cartography and contribute in the improvement of these new alternatives; 5. skill in the management of technical tools for the elaboration of web thematic cartography ; 6. capacity of selection of the strategy suitable for the composition of a map depending on the type of data to represent and their qualities; 7. capacity of synthetic perception of thematic cartography from its applicability and usefulness that contributes to the smart management of the territory.

The methodology of the course is carried out starting from the presentation of contents through video lessons that are complemented with bibliographical material, so that students appropriate the ideas and notions of each thematic module. Due to the course is theoretical and practical, the activities of learning acquire an important weight in its development thus they allow to apply the theoretical concepts exposed, induce to the interpretation and the analysis of the current reality in the mapping of spatial phenomena and stimulate the development of abilities and skills related to the management of cartographic tools.

These activities are structured in learning guides and carried out in each module according to the specific objective for which they are designed and the expected learning result, and prepare gradually to the learner in the development of a final project in which he must design, create and publish a thematic map on a web platform in one of the areas of application of the thematic cartography of his interest, in where the best maps have the possibility to win a prize. The objective of the competition consists that the student presents the most creative, readable and visual

quality map; Similarly, motivate him and awaken him the curiosity to explore more in this area of geomatics knowledge.

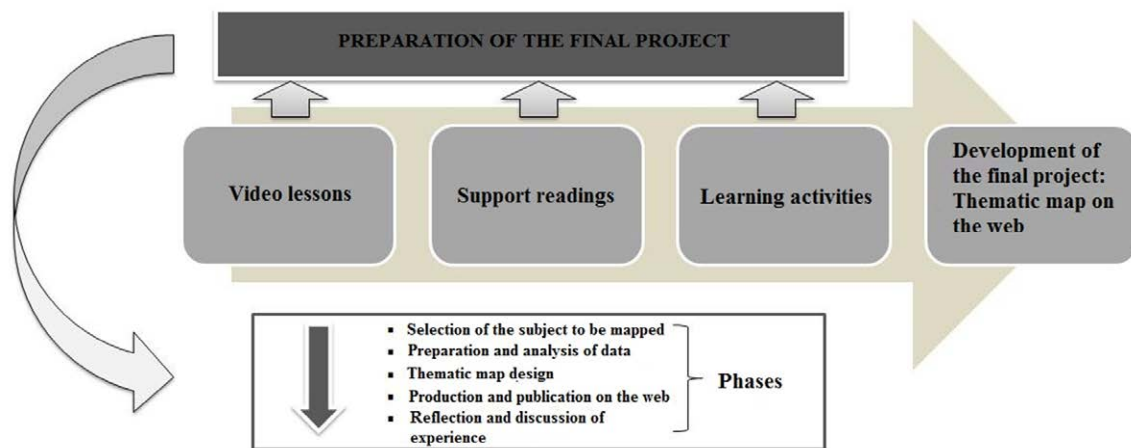


Fig 1. Presentation of the teaching strategy. (Source: Authors)

According to the schema shown in Figure 1, the activities of learning for this pedagogical proposal, which are framed in the educational principle of "learning by doing", are essentially related with:

1. Reflection, considering a situation that describes a cognitive problem in a particular context of the cartography theme, where the student gets a solution in sessions of chat.
2. Identification of conceptual content through the elaboration of questionnaires in which outlined various examples from real situations of mapping of phenomena, evaluating the degree of comprehension and critical analysis reached by the student. The priority in this activity is to provide a feedback to the student.
3. Appropriation of the procedures through the development of theoretical and practical exercises that allow students, to be familiar with the common mapping techniques as well as the use of computer tools and platforms in the cloud, for creation of thematic maps.
4. Activities of specialization, in order to help the student to design, evaluate and build cartographic compositions reaching high levels of understanding, by the stimulation of creativity and consolidation of concepts given in each module of the course.
- 5 Transfer of knowledge, by the discussion of the participants in forums following the outline of collaborative work, where the argument and controversy are the fundamental basis of the pedagogical exercise inside of the virtual classroom. The combination of these aspects aims the student obtains a more active and dynamic learning in this area of the knowledge, that is not totally explored yet, in this type of courses in the country.

On the other hand, this course was built on the system learning "Moodle" of the Universidad Distrital Francisco José de Caldas, free code platform that allows to manage, distribute, and control training courses under the scheme of e-learning (Maes 2010). Likewise, this platform offers facilities and solutions, interactivity, functionality, flexibility, scalability and interoperability that allow in future, to reuse the objects of learning and complete courses.

The technological resources used in the creation of the virtual of learning environment, stated in table 3, were essential elements in the development of the project in the educational terms, choice justified considering the utility that they present in four aspects: the administration of the learning strategy, monitoring training users, creation and maintenance of learning virtual objects and the consolidation of channels of communication (synchronous and asynchronous) between all the participants. Thus, everyone can access to a virtual learning environment free, simple, practical and intuitive designed to learn Thematic Cartography applied to Geosciences that contributes to the pleasant and entertaining interaction between learners, tutors and didactic contents, as is showed in Figures 2 and 3.

Table 3. Presentation of the tools panel

Functionality	Tool	Description
Management objects for virtual learning	Lessons, exercises, tasks, documents, links, glossary	These tools allow the management (creation, import and export) of OVA's in SCORM format. Also stored documents and educational materials to support the learning process.
Management and monitoring of the learning	Didactic programming, survey and evaluation	This set of tools allows manage the academic performance of the student, the skills acquired and the score obtained along the course. Also facilitates the configuration of an electronic calendar for monitoring the important events of the course, the sequence and them, schedules defined for each one of the modules of the course.
Synchronous communication	Chat, Video conference	The chat allows that all participants of the course can communicate in real time using a written language, generate a space for the socialization and the approach of concerns in which the participation is active. On the other hand, videoconferencing allows visual contact. Useful in terms teaching to stimulate the feeling of attendance among students and tutor and the clarification of concepts.
Asynchronous communication	Forum, Wiki, Social Network	Tools selected for discussion and deliberation among students and the tutor. It aims support specific themes in which is required the reflection among students and motivate the exchange of opinions and the construction collective experiences improving in this way the collaborative learning and the cognitive performance (analyze and solve problems proposed by the tutor). In this way the students participate with contributions in explorations and investigations of themes addressed in the course.

Finally, the production of the virtual objects of learning was accomplished from an exhaustive literature review and technical documentation. On the other side the use of technological tools allowed the introduction of graphics resources and multimedia, animations and simulations in order to have a web environment more interactive and informative that enabled the activity of teaching ensuring the transfer of knowledge in this field with at national and international level.

The screenshot shows the first part of a virtual learning environment. At the top is a blue navigation bar with links: UDIN, Mis cursos, PROGRAMAS ACADÉMICOS, DEPENDENCIAS, SERVICIOS, and PLAN DESARROLLO. Below this is a breadcrumb trail: Página Principal > M > O > Cartografía Temática. The main content area is titled 'Cartografía Temática aplicada a las Geociencias' and features a 'SINOPSIS DEL CURSO' section. This section includes logos for the Universidad Distrital Francisco José de Caldas, NIDE (Núcleo de Investigación en Datos Espaciales), and SDI (Sistema de Información Geográfica). A world map displays 'Pentad mean SST (°C): 21-25 May' with a color scale from 1 to 24. A text box explains that thematic cartography involves the study of procedures and guidelines for creating maps that use symbols and signs to represent spatial phenomena. A sidebar on the right contains a 'NAVEGACIÓN' menu with links to the main page, personal area, site pages, profile, and course modules (Participants, Insignias, SINOPSIS DEL CURSO, and Módulos Temáticos 1-4). Below this is an 'ADMINISTRACIÓN' section with links for course administration, grades, changing roles, and profile adjustments.

Fig. 2. Virtual learning environment first part. (Source: Authors)

The screenshot shows the second part of the virtual learning environment. It features a 'PANEL PRINCIPAL' section with a 'Syllabus del Curso' link. Below this are four thematic modules: 'MÓDULO TEMÁTICO 1' (a map of South America), 'MÓDULO TEMÁTICO 2' (a map of the world with a color scale), 'MÓDULO TEMÁTICO 3' (a map of the world with a color scale), and 'MÓDULO TEMÁTICO 4' (a map of the world with a color scale). On the left side of the panel, there are links for 'Foro Social', 'Foro de Inquietudes', 'Chat Global del Curso', and 'Wiki'.

Fig. 3. Virtual learning environment second part. (Source: Authors)

4. Conclusions

The design and implementation of this initiatives, open many possibilities for innovation and constant improvement of educational practices in many areas of knowledge, especially on those who have had minor application such as the thematic cartography, mainly, because they allow to use ICT as an educational tool, using resources and services available on the web, with scenarios of flexible training (regarding the time and the place where the students participate on the e-learning). Likewise, enables the development of competencies defined in the frame of the new paradigm educational, such as the ability to be autonomous, share, compare and give feedback about knowledge acquired.

On the other hand, the result of the evaluation related to performance of the students and the survey satisfaction, confirms the effectiveness of the course, and confirms that the incorporation of technology makes possible the process of learning in any scenario. Its potential is big because the course is oriented to the complementary training considering that the times of academic work are relatively short. However, the implementation of these technologies is also a huge challenge to solve, due three key elements: the availability of the technology needed to meet this type of courses, digital literacy required by the teacher and the student, the desertion of the participants which is a vulnerable element in virtual education, due the lack of habit in the autonomy of the learning, especially in the youth population.

Accordingly, the invitation is to combine efforts that arise to improve the teaching practice, appropriating ICT, in order to reduce the limitations and strengthen the free transfer of knowledge with high quality, even in Geomatics fields and Earth Sciences, where the need of training and updating is significant.

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References

- Kolb, D. (1981). Learning styles and disciplinary differences. *The modern American college*, 1, 232-255.
- Bertin, J. (1987). "La gráfica y el tratamiento gráfico de la información". Taurus Ediciones.
<https://dialnet.unirioja.es/servlet/libro?codigo=71971>
- Kruse, K. (2002). "Introduction to instructional design and the ADDIE model". Retrieved January, 26, 2005.
- Ibáñez, J. S. (2004). "Innovación docente y uso de las TIC en la enseñanza universitaria". *Universities and Knowledge Society Journal*. Volume 1. Page 3-7.
- Parra, J. (2005). Educación virtual. Reflexiones y experiencias. Medellín: Fundación Universitaria Católica del Norte. Recuperado de <http://www.ucn.edu.co/institucion/sala-prensa/Documents/educacion-virtual-reflexiones-experiencias.pdf>
- Coll, C. (2008). "Aprender y enseñar con las TIC: expectativas, realidad y potencialidades". *Boletín de la Institución Libre de Enseñanza*. Volume 72. Pages 17-40.
- Cortés, J. C. (2009). "Los tres escenarios de un objeto de aprendizaje". *Revista iberoamericana de educación*, 50(1), 2.
- Maes, J. M. (2010). "Chamilo 2.0: A Second Generation Open Source E-learning and Collaboration Platform". *iJAC*, 3(3), 26-31.
- Bas Peña, E. (2011). "Aprendizaje basado en problemas". *Cuadernos de pedagogía*, (409), 42-44.
- Belloch, C. (2012). "Diseño instruccional". Unidad de tecnología educativa. Universidad de Valencia.
<http://www.uv.es/bellochc/pedagogia/EVA4.pdf>
- Ghirardini, B. (2014). "Metodologías de E-learning: una guía para el diseño y desarrollo de cursos de aprendizaje empleando tecnologías de la información y las comunicaciones". FAO. http://www.fao.org/elearning/Sites/ELC/Docs/FAO_elearning_guide_es.pdf

- Marín, D. (2015). "Formación por competencias". Unaciencia, (4).
<http://revistas.unac.edu.co/index.php/Unaciencia/article/viewFile/70/49>
- Krathwohl, D. & Bloom, B. (1964). Taxonomy of educational objectives. David McKay Company.
- Felder, R. M., & Silverman, L.K. (1988). Learning and teaching styles in engineering education. *Engineering education*, 78(7), 674-681
- Flórez, A., & Thomas, J. (1992). "Las variables visuales en cartografía temática". Revista Cartográfica. Instituto Panamericano de Geografía e Historia (IPGH). Volume 61. Páginas 5-39.
- Valle López, G., & López, M. B. (2005). "Las TIC y el trabajo colaborativo en el proceso enseñanza-aprendizaje en el nivel universitario". I Congreso en Tecnologías de la Información y Comunicación en la Enseñanza de las Ciencias.
<http://sedici.unlp.edu.ar/handle/10915/19531>
- Orduz, R.; Díaz, P.; Medina, L.; Ayala, L.; Ospina, O.; Vallejo, E. (2012). "Sociedad del Conocimiento y Tecnologías de la Información". Aprender y educar con las tecnologías del siglo XXI. Corporación Colombia Digital. ISBN 978-958-99999-2-9. Páginas 9-12.
<http://www.deltaasesores.com/documentos/AprenderyEducar.pdf#page=9>